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FINAL REPORT FOR BLUE SCOUT JUNIOR FLIGHT 02

by

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ABSTRACT

This document contains the results of the Blue Scout Junior Flight 0-2 (PMR Test Code A), which was launched from Pt Arguello, Pacific Missile Range, on 4 December 1961.

Although this flight was unsuccessful, data were obtained from FPS-16 skin track radar, which is accurate until second-stage burnout, and from TLM-18 signal strength data. Since no vehicle instrumentation was aboard this flight, causes of failure cannot be accurately determined. Motor and component performance is described as far as possible from the data available.

PUBLICATION REVIEW

This report has been reviewed and is approved.

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1. INTRODUCTION.

This report presents the results of Blue Scout Junior Flight Test Number 0-2 (PMR Test Code A.)

The test vehicle was of 2356 configuration, commonly called a "Blue Scout Junior;" this four-stage, solid-propellant, unguided missile is shown in figures 1 and 2.

0-2 was the fourth flight of the Blue Scout Junior series. Three earlier flights were launched during September 1960, November 1960, and August 1961.

Scientific instruments were provided by the Physics Division, with telemetry buildup, payload integration, and range documentation and coordination performed by the Special Projects Division. Both of these organizations are under the Research Directorate, AFSWC, Kirtland AFB, New Mexico. Assembly of the vehicle and the launch operations were conducted by the 6555th Aerospace Test Wing, Patrick AFB, Florida.

Table 1

TIMING SEQUENCE

EVENT	ACTUAL	PROGRAMED
1. First stage ignition	T+0	T+0
2. Spin rocket ignition	T+0.87	T+0.83
3. Second stage ignition	T+37.70	T+37.09
4. Nose cone ejection	T+82.76	T+81.80
5. Third stage ignition	-	T+82.80
6. Fourth stage ignition	T+115.22	T+115.80

Note: Actual time of the spin rocket firing was taken from photographic data; other actual times were obtained from analysis of telemetry signal strength records.

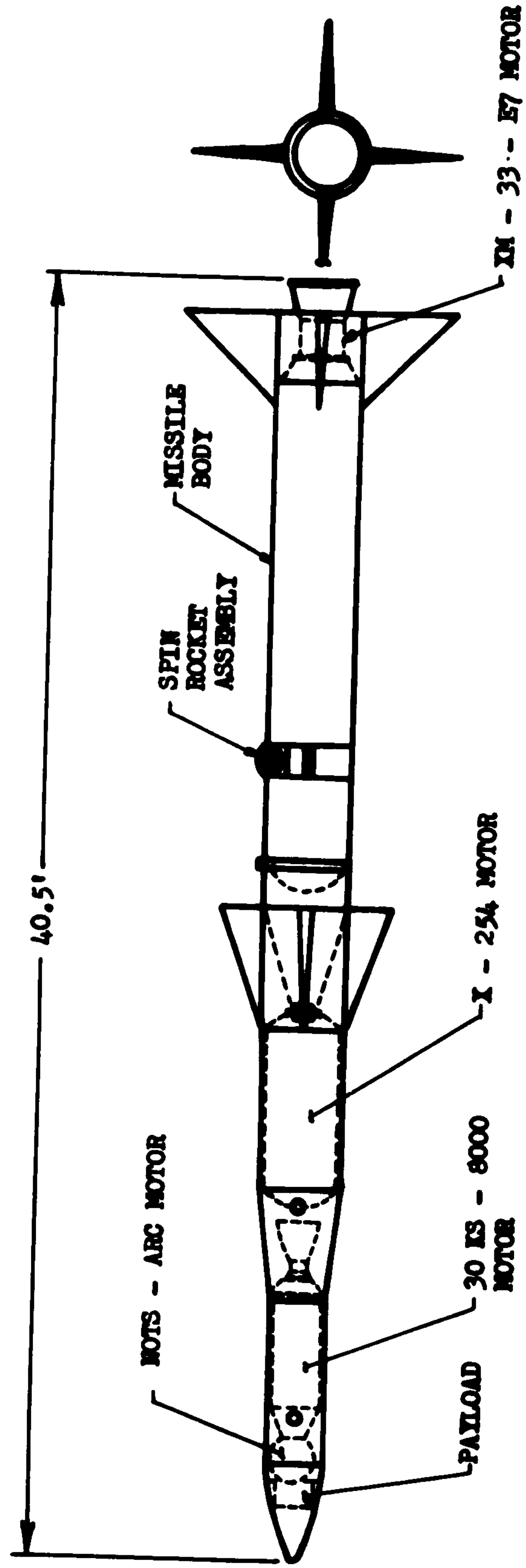


Figure 1. Blue Scout Junior configuration (2356)

Figure 2. Blue Scout Junior

The vehicle was launched from the NERV launch pad at Pt Arguello, Naval Missile Facility, Pacific Missile Range, at 1200:19.339 Z on Monday, 4 December 1961. The vehicle launcher was set to provide an effective launch azimuth of 185 degrees and an effective launch elevation of 72 degrees. The vehicle was aerodynamically and spin stabilized along a gravity-turn trajectory during the powered flight portion of the first two stages and was spin stabilized along a constant attitude trajectory during the third- and fourth-stage powered flight and during coast through apogee to reentry.

The primary test objective was to measure low energy proton flux (solar wind) in regions beyond the outer radiation belt. The preflight computed apogee was 24,000 nautical miles at T+372 minutes at latitude 70 degrees south and longitude 152 degrees east.

2. SUMMARY OF TEST RESULTS

The ballistic trajectory of this flight is unknown because of the lack of vehicle instrumentation and the failure of any TLM-18 except the one at Vandenberg AFB to acquire the telemetry signal (see section 5). Telemetry data, however, indicate an unusual occurrence at or near fourth-stage ignition (see section 4b).

The actual powered portion of the flight path was high and to the left of that predicted; the main source of error is explained in section 3.

The payload, composed of instruments to measure radiation in space, weighed 28.5 pounds.

The launcher conditions at liftoff were

Azimuth angle:	188.050 degrees
Elevation angle:	69.732 degrees

These corrected angles were to negate wind effects so as to realize a flight path corresponding to nominal launcher settings of 185 degrees azimuth angle and 72 degrees elevation angle.

The following is a summary of important portions of the test:

Subject	Test results
Performance	(1) The first three stages performed nearly as predicted. (2) Velocity was close to predicted values for the first two stages. (3) Velocity for the third stage was close to predicted values until the skin track radar data became unreliable.
Dispersion	(1) Flight path was high and to the left of the predicted flight path through second-stage burning. (2) First-stage impact was outside the assigned impact area because of the high velocity, upper-altitude winds, and a tumbling reentry. (3) Second-stage impact was within the three-sigma impact area.
Propulsion	(1) All motors were visually observed to ignite. (2) First three stages performed close to preflight estimates up to the tracking limit of radar reliability. (3) Spin motors ignited. (4) First-, second-, and third-stage motors did not exhibit a large thrust misalinement.
Air frame	(1) No structural failure was evident in the first three stages. (2) Separation of the first and second stages and separation of the second and third stages were as expected.
Electric/electronic	(1) The ignition system performed satisfactorily. (2) DIGILOCK performed satisfactorily.

3. VEHICLE FLIGHT PERFORMANCE.

a. Flight data comparison.

Displacement histories for the first three stages taken from radar and theodolite data are compared with the preflight estimate of the path of the vehicle in figures 4 through 11.[1] Theodolite data exist through 40 seconds. These histories are presented in range coordinates which consist of a left-hand orthogonal set of axes, as shown in figure 3, in which the downrange axis (X-axis) and the crossrange axis (Y-axis) are in the true tangent plane at sea level under the launch pad, moving with the launch pad. The X-axis is along a true azimuth of 185 degrees.

The data indicate that the vehicle flew above and to the left of the predicted path. At approximately 100 seconds the data became inaccurate because the skin track radar was unable to track at distances exceeding 100 nautical miles.

All preflight trajectory calculations were made using a 30-pound payload, but the true payload weight was only 28.5 pounds. As a result of this difference the true path of the vehicle varied from the nominal to a small extent.

The total velocity with respect to the launch point is shown in figure 12. Here it may be seen that the vehicle flew close to the predicted velocity until the skin track radar data became unreliable. It should be noted that, since the vehicle flew a more vertical path than intended, the velocity should have been slightly lower because of the larger gravitational loss.

The velocity vector elevation and azimuth with respect to the range coordinates are presented with the preflight estimates in figures 13 and 14. For a nominal initial vector elevation of 72 degrees, a launcher setting of 69.732 degrees was used based on winds at T-35 minutes. The increase in winds during the 35 minutes before launch would have required a setting of 69.005 degrees, which would have produced a vector elevation angle closer to nominal. The vector azimuth was left of the nominal initial vector azimuth of 185 degrees. The launcher setting of 188.050 degrees was based on the winds at T-35 minutes. However, the increased winds during the 35

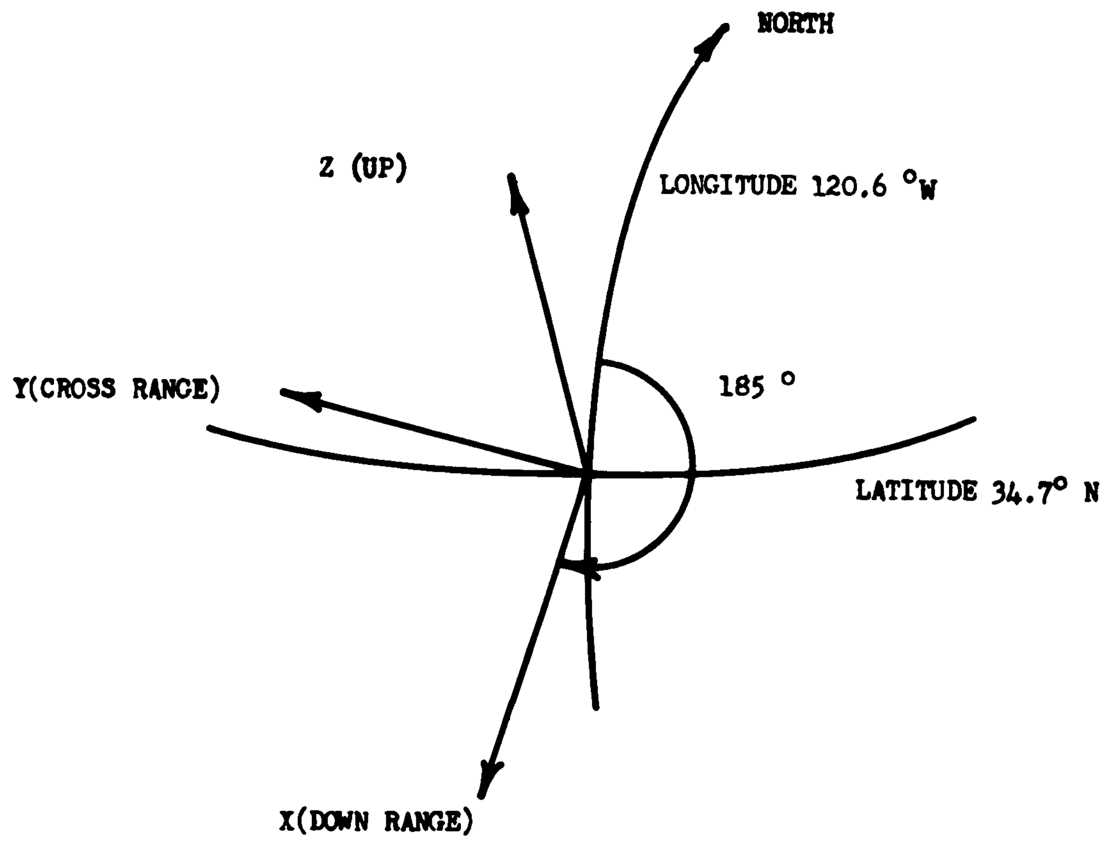


Figure 3. Range coordinate system

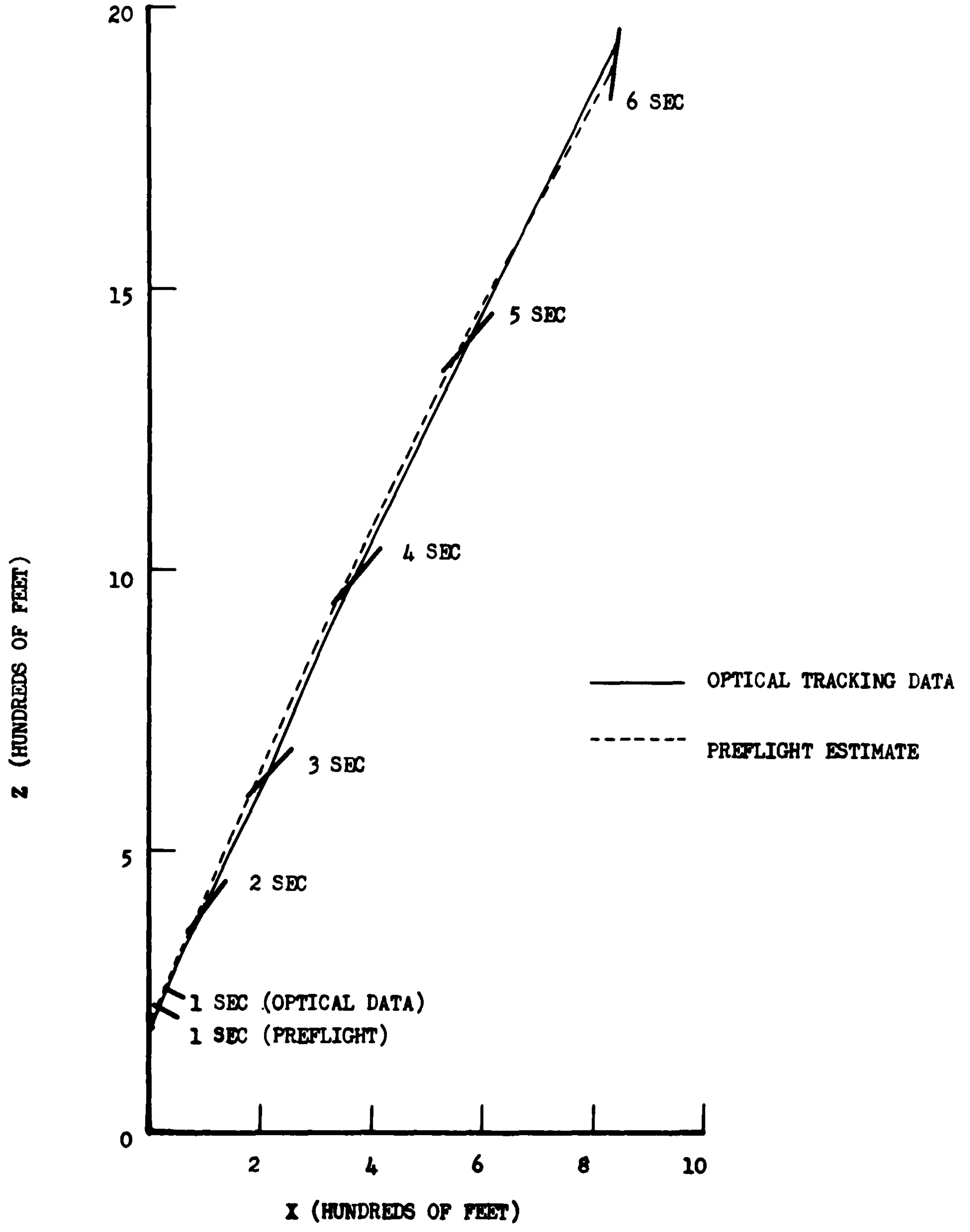


Figure 4. Blue Scout Junior (0-2)-position data-0 to 6 seconds

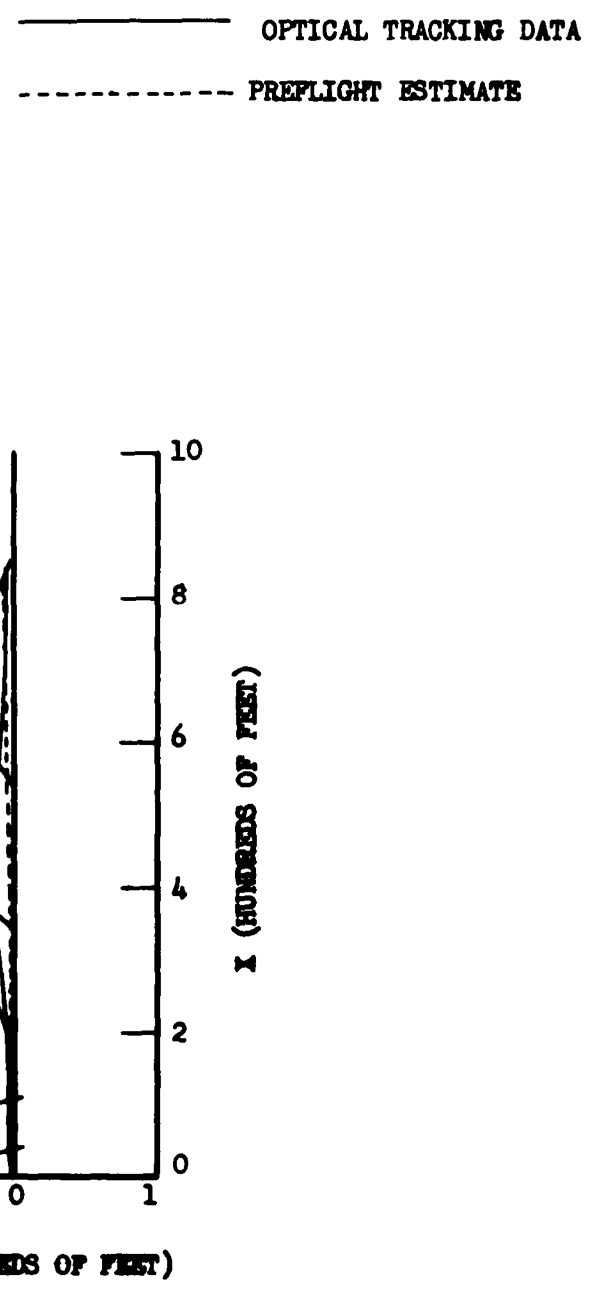


Figure 5. Blue Scout Junior (0-2)-position data- 0 to 6 seconds

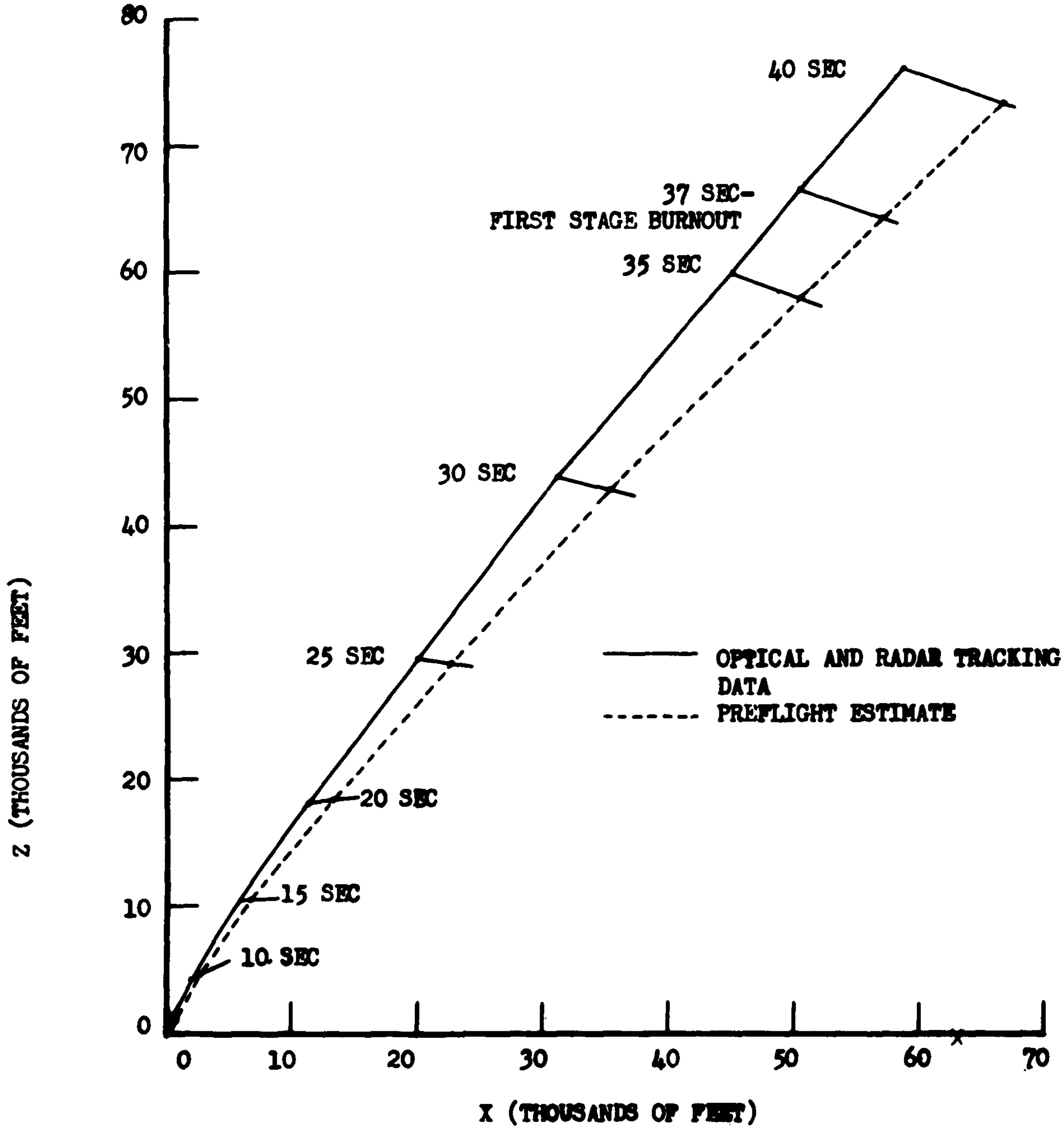


Figure 6. Blue Scout Junior (0-2)-position data- 0 to 40 seconds

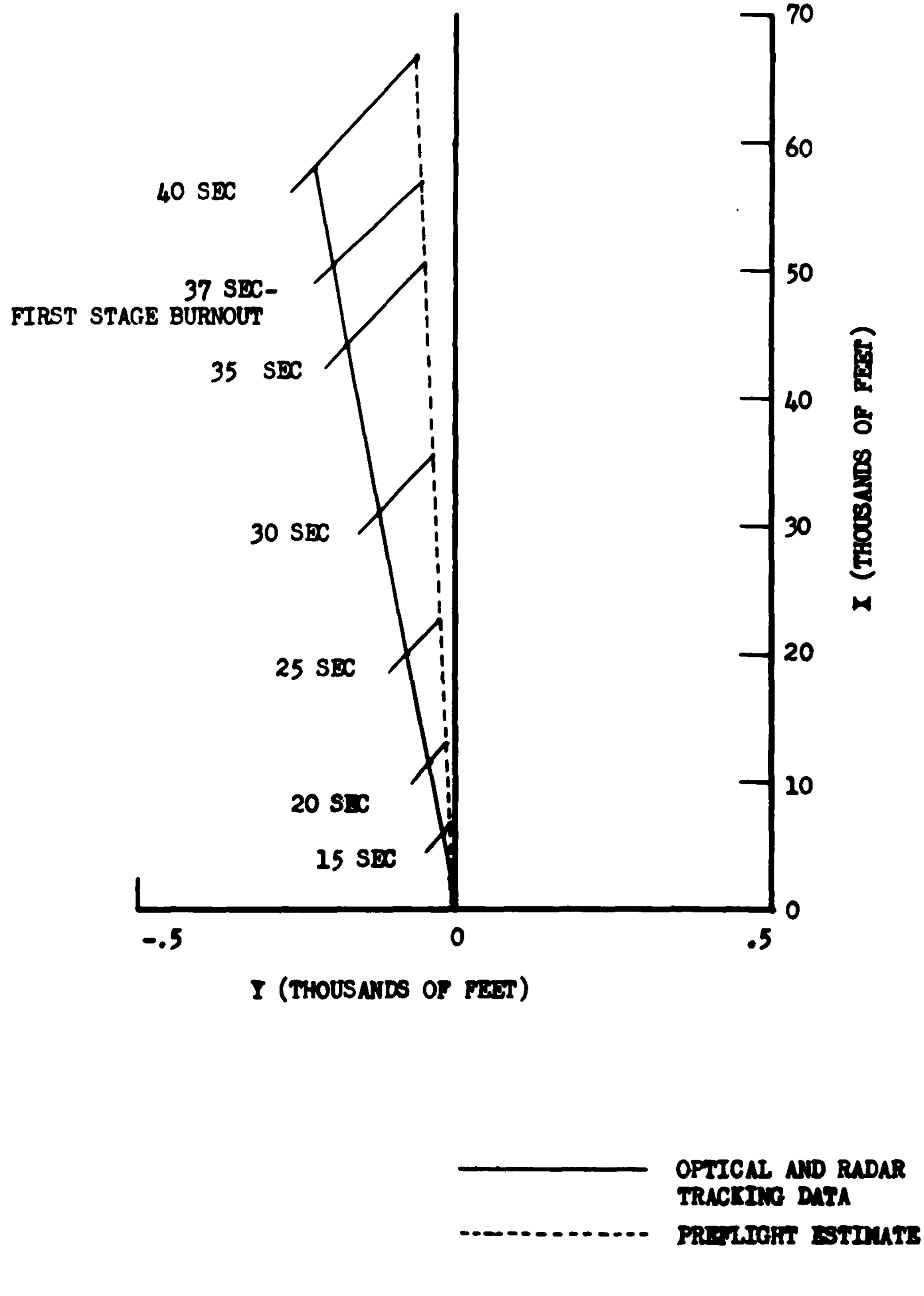


Figure 7. Blue Scout Junior (0-2)-position data- 0 to 40 seconds

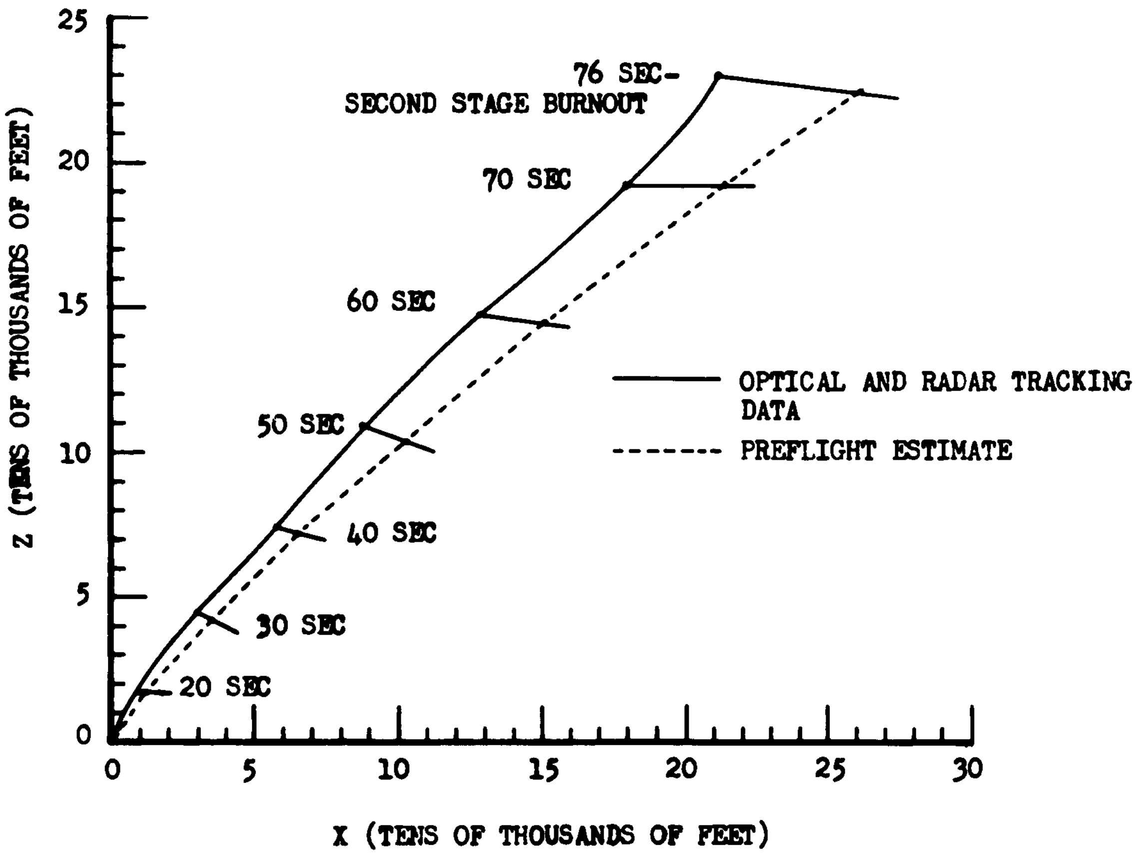


Figure 8. Blue Scout Junior (0-2)-position data- 0-76 seconds

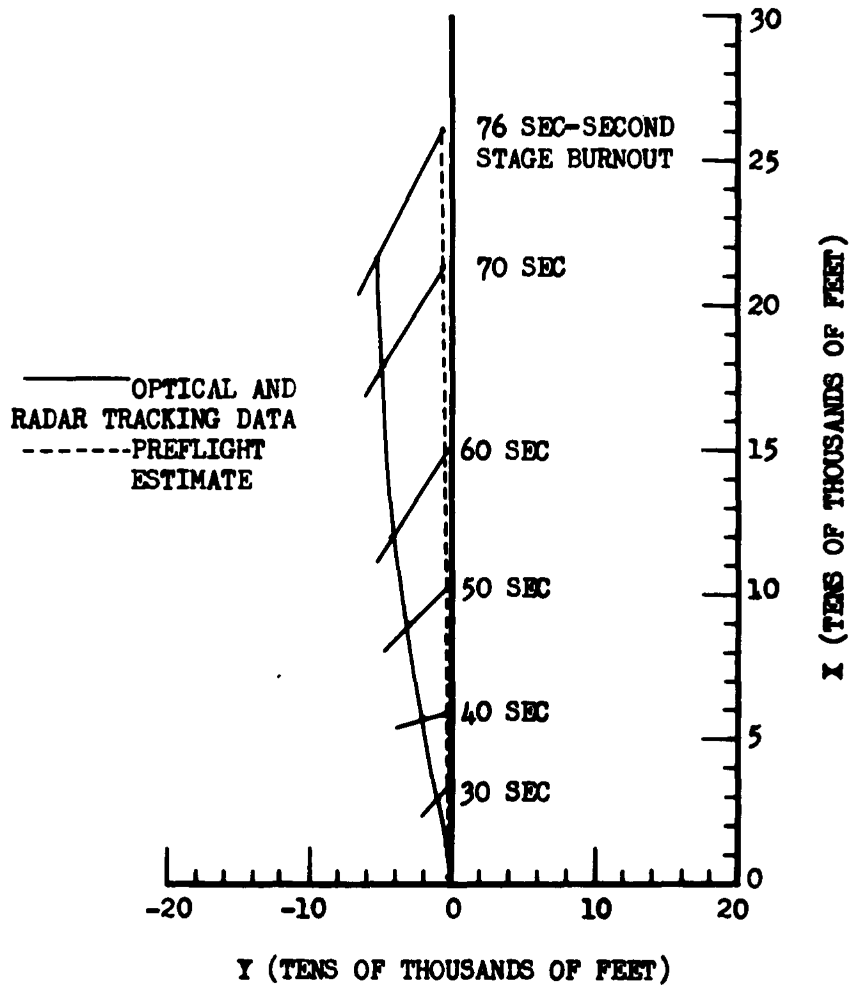


Figure 9. Blue Scout Junior (0-2)-position data- 0 to 76 seconds

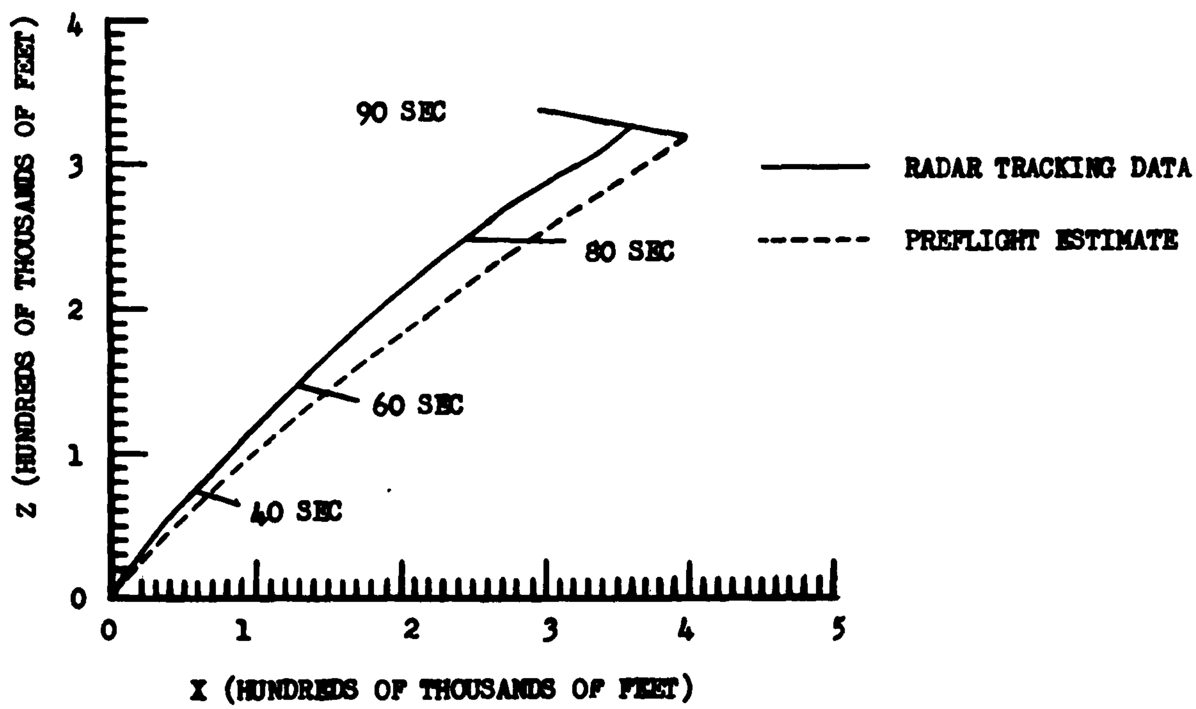


Figure 10. Blue Scout Junior (0-2)-position data- 0 to 90 seconds

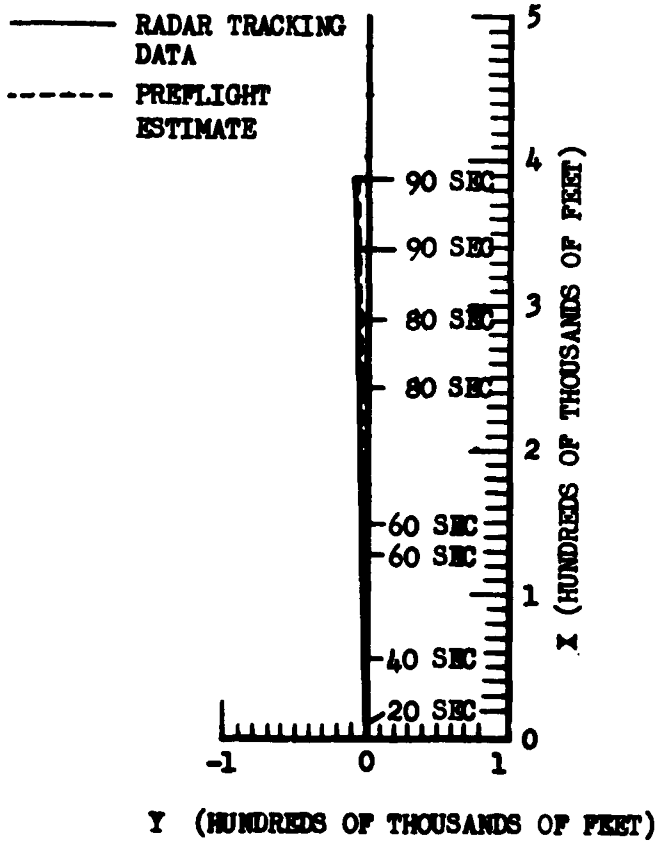


Figure 11. Blue Scout Junior (0-2)-position data- 0 to 90 seconds

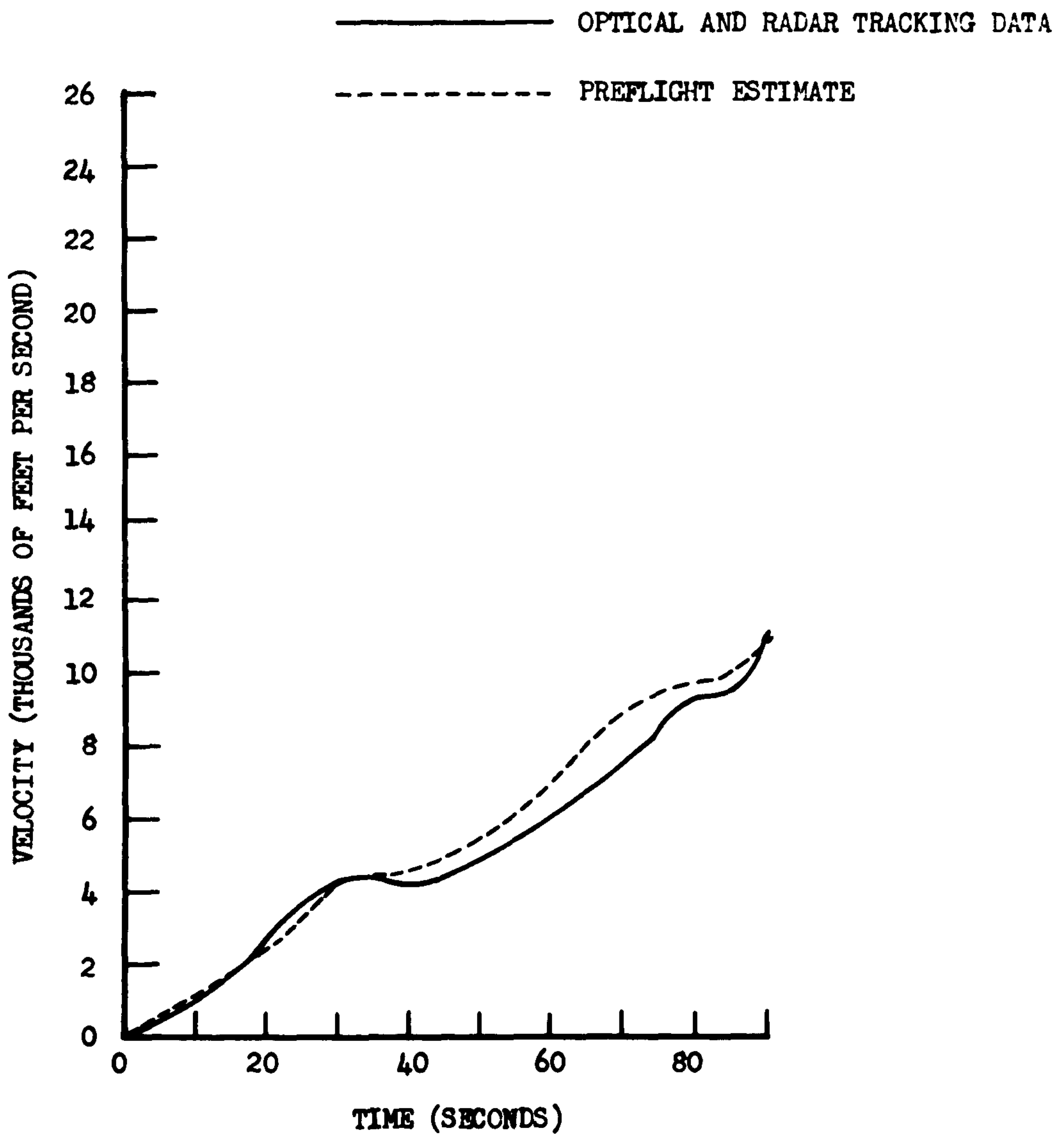


Figure 12. Blue Scout Junior (0-2)-velocity data- 0 to 90 seconds

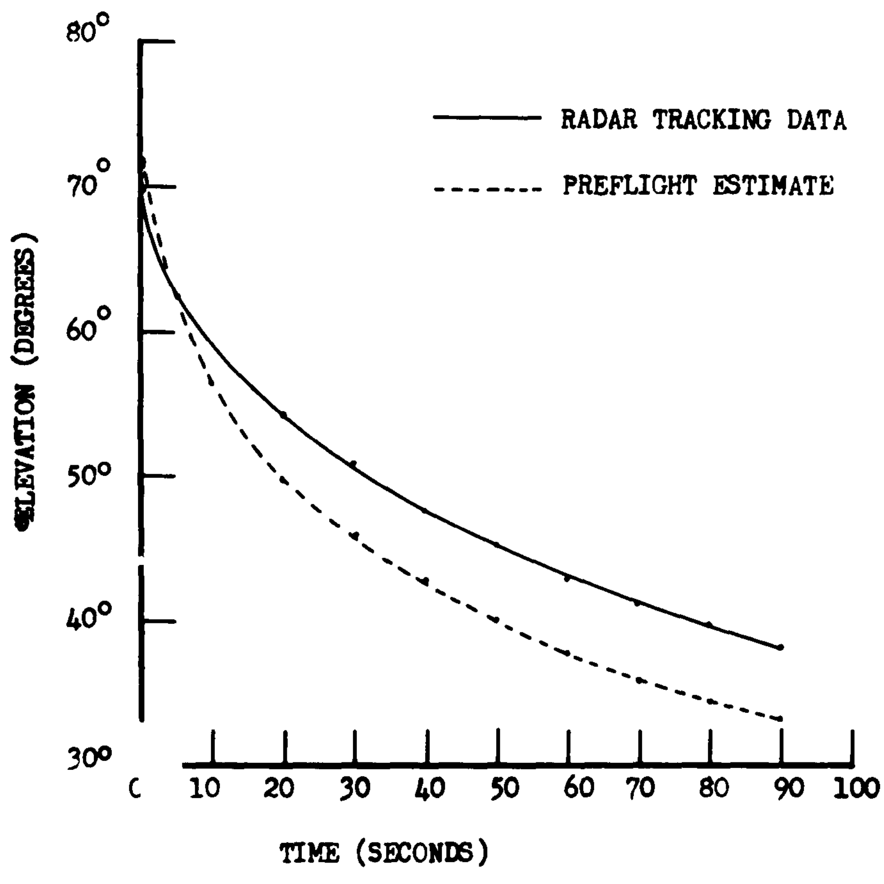


Figure 13. Blue Scout Junior (0-2)-elevation of velocity vector with respect to range coordinates, 0 to 90 seconds

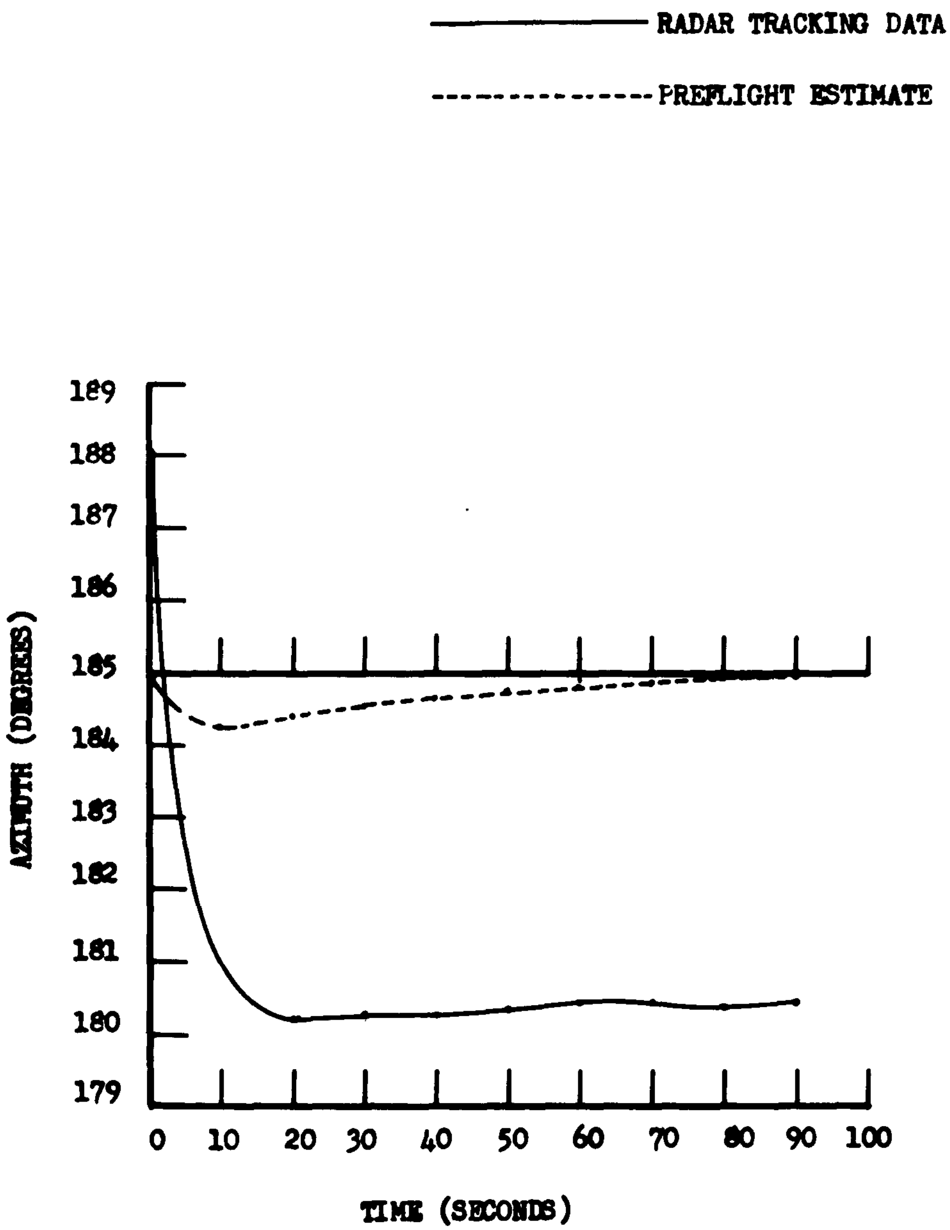


Figure 14. Blue Scout Junior (0-2)- azimuth of velocity vector with respect to range coordinates, 0 to 90 seconds

minutes before launch would have required a setting of 189.432 degrees which would have produced an azimuth closer to nominal.

Vehicle roll rate is presented in figure 15. This value is determined by analysis of telemetry signal strength, since there was no vehicle instrumentation to record these data. The reduced analyzed data indicate the roll rate was normal through third-stage burning.

Since there was no vehicle instrumentation aboard this flight, it was impossible to obtain continued accurate information concerning vehicle performance. The only data available are the radar and optical tracking data from the Range Operations Department of PMR and the signal strength data obtained from the telemetry recordings.

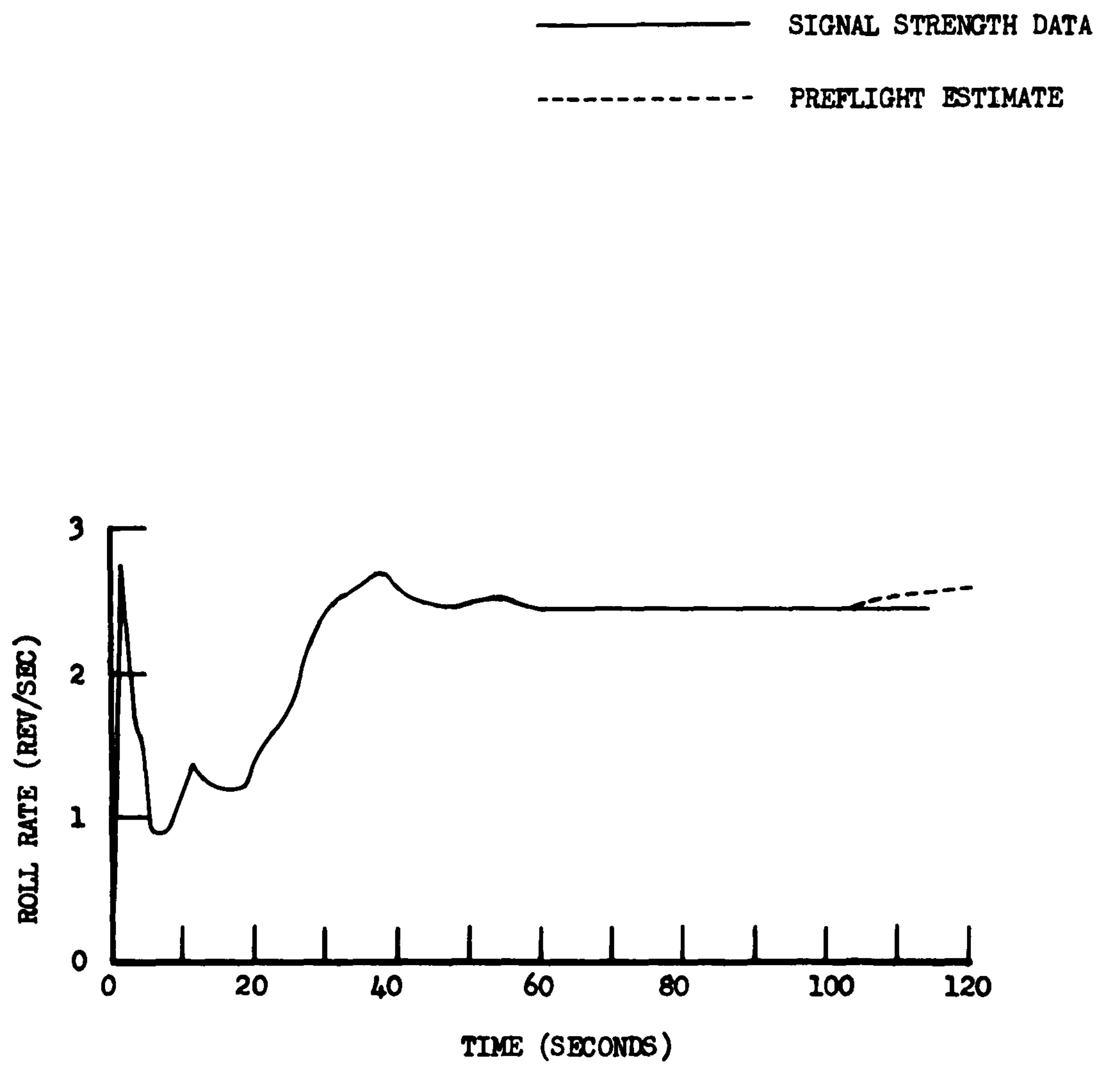
At T+90 to T+100 seconds, the radar skin track data became erratic. This condition can be attributed to the inability of this type of radar to skin-track so small an object at so great a distance. In this period, however, no abnormal conditions were exhibited by the radar results. Since these data did not become erratic until well into third-stage burning, it can be assumed that vehicle performance was normal up to that point.

The signal strength data showed no abnormal conditions until T+115.22 seconds, which is the time of fourth-stage ignition. At that time FPS-16 radar data are completely unreliable and signal strength data provided the only key to vehicle performance. This information and its analysis are contained in section 4.

b. Dispersion.

(1) General.

The nominal launch conditions are a true azimuth of 185 degrees and an elevation angle of 72 degrees. However, the predicted ground track for Blue Scout Junior does not coincide with the extended 185-degree azimuth line, primarily because of gyroscopic effects. The effects have been computed and are evinced in reference 1, Trajectory and Aerodynamic Information for Blue Scout Junior, PMR Test Code 0-2, Volume II, in columns titled "Deflection" and "Y" for the powered phase.



Note: The preflight estimate and the results of the signal strength analysis coincide from T+0 seconds to T+100 seconds.

Figure 15. Blue Scout Junior (0-2)- roll rate

Predicted vehicle performance and stage impacts for Blue Scout Junior include predicted gyroscopic effects.

(2) Wind weighing solution.

Impact for the first stage is based on radar data obtained from PMR. Figures 16 and 17 describe the trajectory for the spent first stage. As seen in figure 16, the impact point was approximately 3,000 yards short of the assigned range impact area and to the left of the nominal, although it was well within the cumulative failure impact area.

This variation from the nominal trajectory can be accounted for by several reasons. The early prognosis of upper altitude winds in the area called for westerly winds up to 70 knots. Since the launch was set for a payload azimuth of 185 degrees, the first stage was expected to impact east of the nominal impact point. Because of these high winds at apogee, the first stage began to tumble at approximately 100 seconds. The tumbling body, with its increased drag, assumed a new trajectory of shorter range than the original trajectory of a nontumbling body. The change in trajectory caused by the tumbling is shown in figure 17. Moreover, the tumbling body was more affected by the side wind, which caused it to deviate even farther to the left of the nominal than the nontumbling body. This increased deviation to the left can be seen in figure 16.

Figure 18 shows the computed impact of the second stage. This impact point was determined from the actual second-stage burnout conditions and lies well within the three-sigma dispersion area.

Final launcher corrections were made at T-35 minutes, and, based upon the winds at that time, the calculated settings were as follows:

Azimuth angle:	188.050 degrees
Elevation angle:	69.732 degrees

c. Flight path errors.

Data and initial flight coverage do not indicate abnormal occurrences such as excessive thrust misalinement or launcher tip-off moments.

Based upon the winds at launch time, the final launcher settings

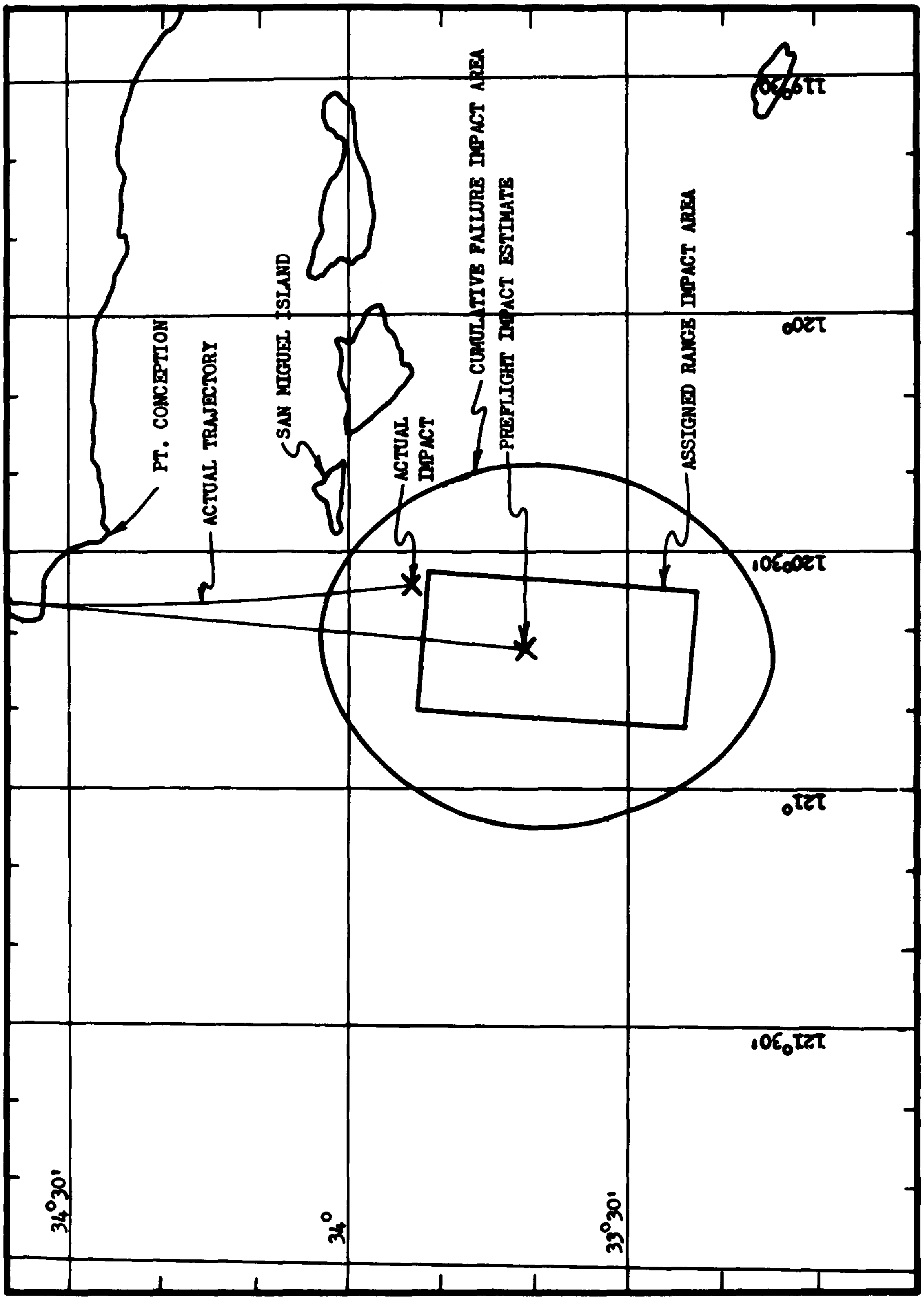


Figure 16. Blue Scout Junior (0-2)- first-stage impact and dispersion

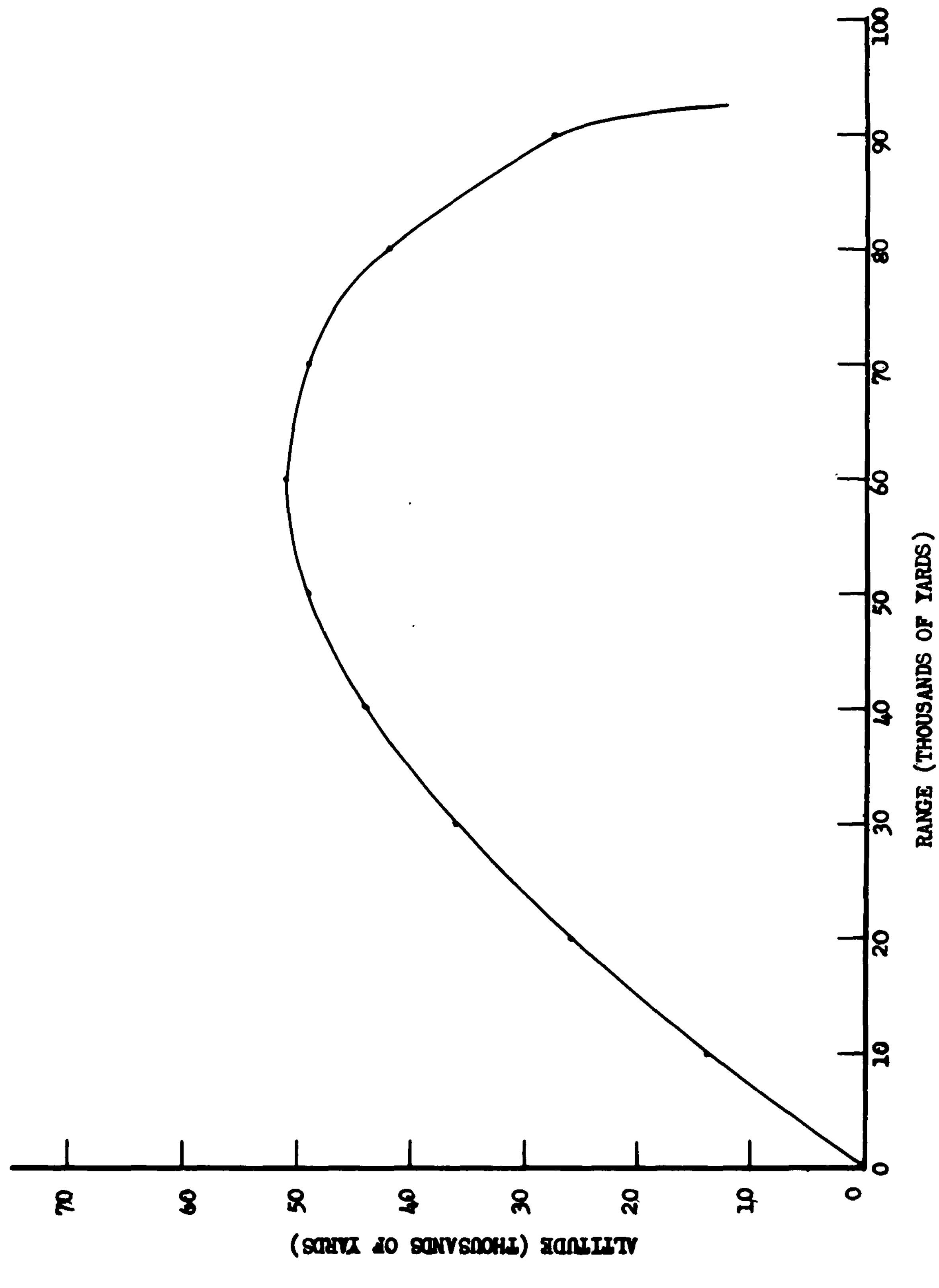


Figure 17. Blue Scout Junior (0-2)- first-stage trajectory

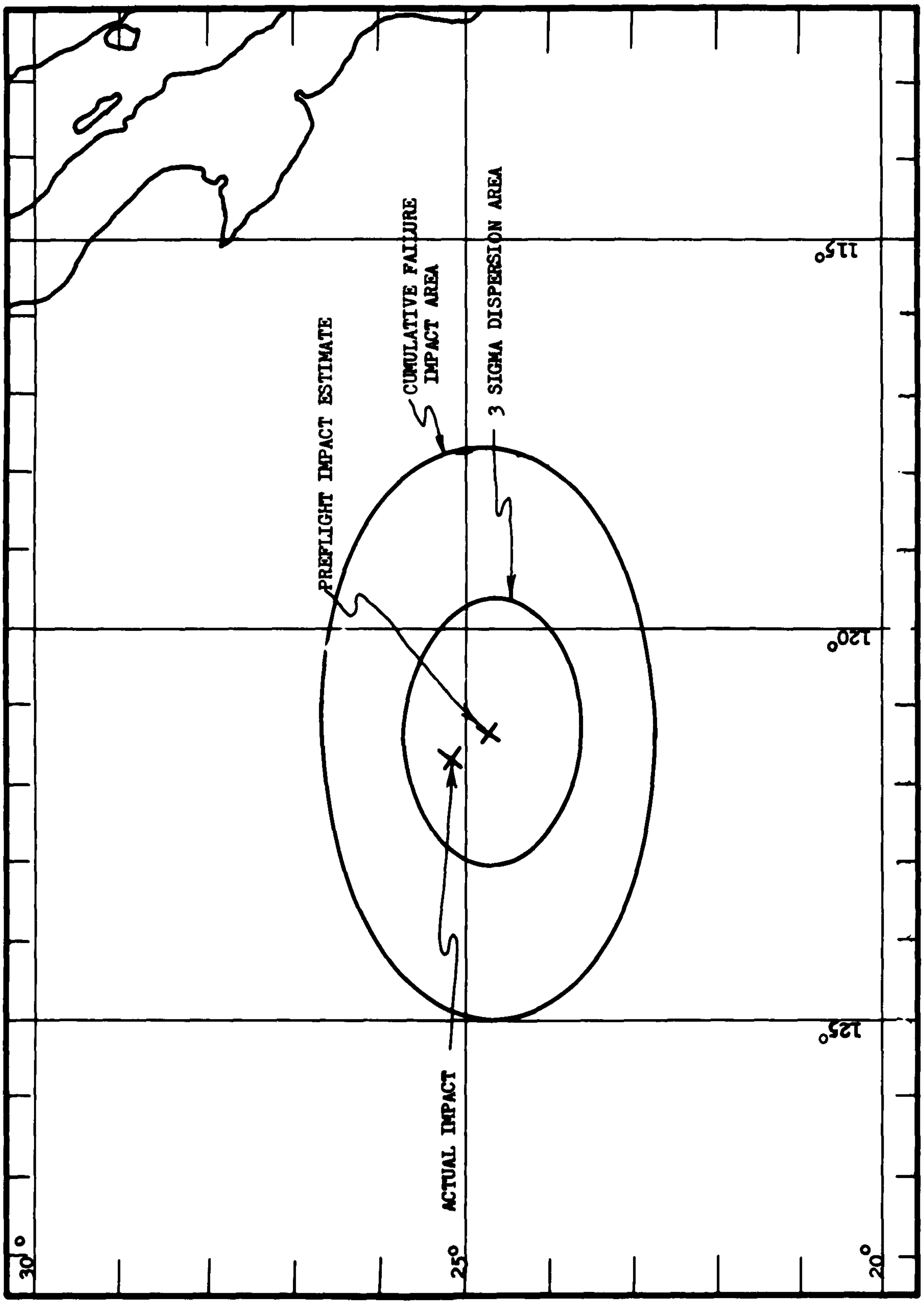


Figure 18. Blue Scout Junior (0-2)- second-stage impact and dispersion

should have been as follows:

Azimuth angle:	189.432 degrees
Elevation angle:	69.005 degrees

4. TELEMETRY.

a. Theoretical signal strength calculations.

Transmitter output: 250 milliwatts = + 24 dbm

Transmitting antenna gain: + 1 db (up to 25 degrees away from the tail look angle)

+ 4 db (up to 8 degrees away from the tail look angle)

Note: These gain figures are for the antennae in the NOSE CONE OFF position.

Space attenuation for 200 nautical miles (estimated 4th stage ignition slant range)

$$37 + 20 \log f + 20 \log d = 130.9 \text{ db}$$

Effective antenna and preamp gain of the receiver:

Pt Arguello:	20 db (Quad helix)
Vandenberg:	30 db (TLM-18, 60-foot dish)

Theoretical signal strength at the receiver:

Pt Arguello:	-86 dbm (10 microvolts)
Vandenberg:	-76 dbm (35 microvolts)

Three TLM-18 stations were programed to track the Blue Scout Junior (0-2) flight: Vandenberg AFB, California; South Point, Hawaii; and Woomera, Australia. Each of these stations had been provided with the appropriate azimuth and elevation angles for the entire nominal flight path of the scientific payload.

When the South Point and the Woomera TLM-18's failed to acquire the telemetry signal, both stations were assigned scan sectors. These included all conditions of fourth-stage motor performance from nominal burning to failure to ignite.

However, only the Vandenberg AFB TLM-18 acquired the signal from the scientific payload.

b. General.

Actual signal strength records made at Vandenberg AFB were taken from the TLM-18 tracking loop receiver. A 10-cycle nutation, induced into the tracking loop to provide an error signal for the autotrack system, is apparent in these records. Both AFSWC DIGILOCK receivers at Vandenberg had signal lock for about 2 minutes after the Vandenberg tracking loop receiver had lost the signal. AFSWC receiver operators at Vandenberg saw no visible indications of violent periodic signal dropouts during fourth-stage burning. AFSWC receivers were saturated until horizon loss of the signal at T+ 19.8 minutes. Trajectory data, azimuth, and elevation from the TLM-18 were provided every 4 seconds on punched tape by the Vandenberg station.

Signal strength records taken at Pt Arguello were a standard 100-kc BW telemetering receiver. The quad-helix antenna system was manually operated with corrections being determined by visual observation of the signal strength meters. No trajectory data were supplied by this station.

The one AFSWC receiver at Pt Arguello maintained "lock" until line-of-sight loss of the signal, which was coincident with the loss of signal at Vandenberg at T+ 19.8 minutes. Lock was acquired again for a period of about 10 seconds at approximately T+ 26 minutes. This was probably due to a freak propagation condition and may have occurred upon payload reentry. The AFSWC receiver at Pt Arguello experienced severe periodic dropouts at a frequency of about two per second from about T+ 116 seconds to loss of signal. The perturbations were drops in signal strength of 15 db to 20 db based on the quad-detector calibrations.

Actual signal strength at Vandenberg at T+ 116 seconds was approximately 21 microvolts which is equivalent to about -80 dbm. This value is within 4 dbms of the -76 dbm which was predicted in the first part of this section. Therefore, this value is considered valid.

Actual received signal strength from Pt Arguello is not attainable, since signal strength calibrations were not placed on tape. However, all indications are that signal strengths at T+ 116 seconds were about 7 microvolts (-90 dbm) which is consistent with the predicted theoretical value of -86 dbm as shown in the first part of this section. The antenna patterns indicate that antennae extended normally after nose cone eject.

The signal dropouts observed at Pt Arguello from about T+ 116 seconds to the loss of signal were periodic in nature. As shown in figure 19, the period of this dropout was about one-half second. The best explanation of this dropout is fourth-stage wobble or precession. Antenna damage or lobing can be ruled out, based on satisfactory operation up to T+ 116 seconds. The dropouts then are most likely due to periodic look angles at the payload, which was in such an attitude as to present a null to the receiving station. The antenna pattern shows that nulls of -20 db can be expected at angles of 55 degrees from the tail of the vehicle. These pattern nulls become increasingly severe as the angle increases, reaching a minimum of some -48 db at an angle of 130 degrees from the tail of the vehicle. From indications of the quad-detector current variations on the AFSWC receiver at Pt Arguello, it is estimated that the periodic dropouts were signal strength changes of at least 20 db. It is concluded, then, that the payload was wobbling through an angle of at least 55 degrees from its principal spin axis. These dropouts are apparent on signal strength records from Vandenberg, although the greater antenna gain there served to minimize these effects.

No firm conclusions can be reached from signal strength records as to fourth-stage malfunction. It is shown that all operations appeared normal up to fourth-stage ignition and that ignition, or a similar event, did occur.

c. Telemetry and payload data.

This was the first flight of the DIGILOCK telemetering system. All indications are that the DIGILOCK system performed normally. A payload function scheduled to occur at T+ 35 minutes was not observed, since telemetry data were received only through about T+ 20 minutes. This payload function was to turn on a 5-kv power supply and subsequently activate four "open window" photomultiplier tube low energy particle detectors.

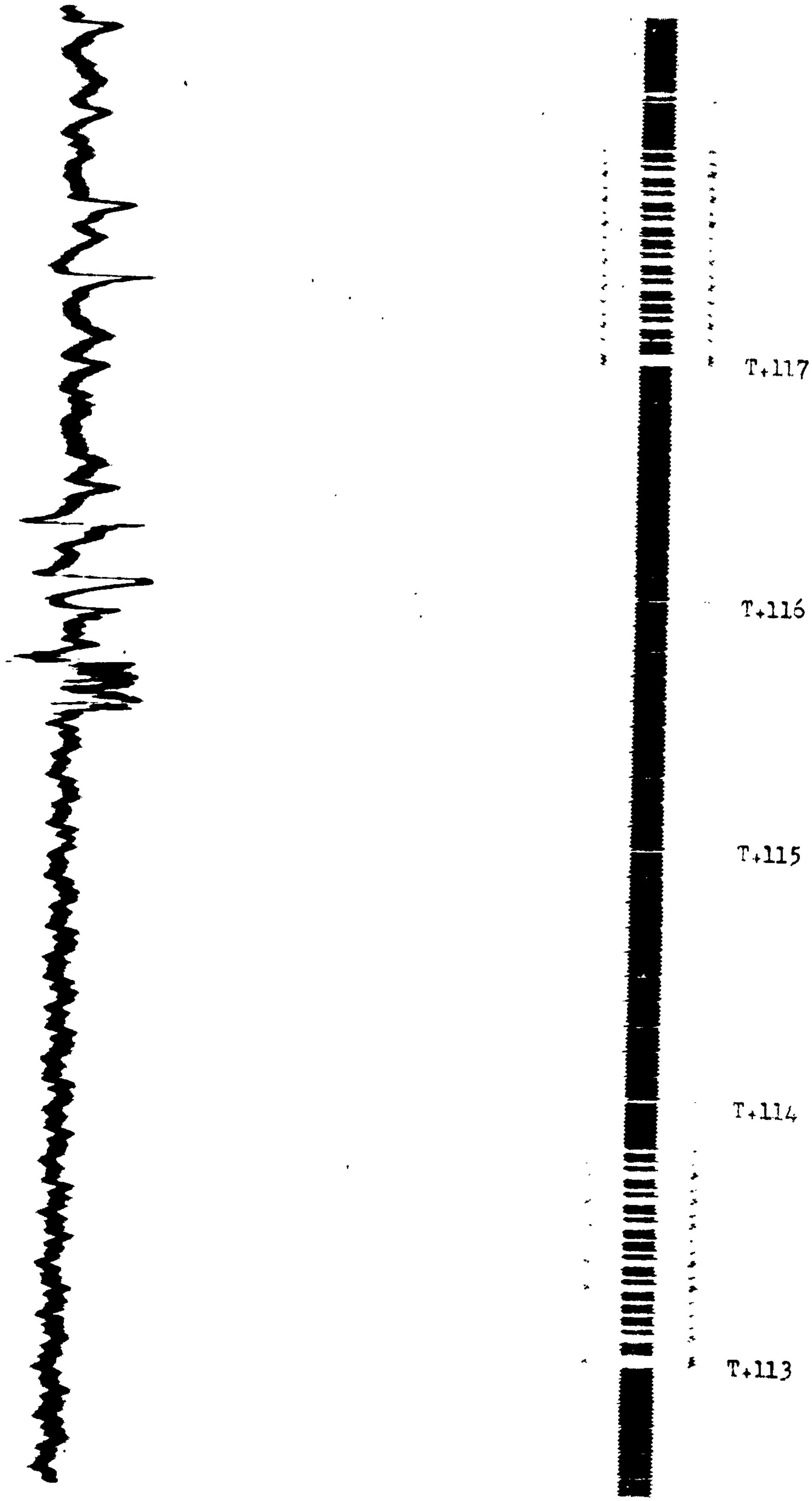


Figure 19. Blue Scout Junior (0-2) signal strength

Four solid state detectors were operating through the period of the flight and registered some counts. Telemetered DIGILOCK data for the flight have been reduced and no errors were present. The experimenter, Dr. Palmer Dyal, states that he is unable to give an estimate of the altitude reached by the probe on the basis of the payload data received.

5. CONCLUSIONS AND RECOMMENDATIONS.

a. DIGILOCK.

In general, the complete DIGILOCK system (i.e., flight unit, ground receivers, decoding process) performed up to expectations. This was not a full range test (maximum slant range estimated at 2,000 miles), since the system flown had a potential of some 50,000 miles. Performance was considered satisfactory to the extent that AFSWC will fly the DIGILOCK system on three FY 63 probes to 70,000 miles. Solutions to operational problems encountered are also in process. Principal problems were the following:

(1) Deployment of special receivers with AFSWC operators.
(2) Difficulties in receiver alinement.
(3) Readout of data and correlation with instruments by hand-decoding of oscillographs.
(4) Ascertainment of correct received signal-strength in the presence of high-power transmissions (0-2 transmitter [illegible] an output power of 250 milliwatts).

It is recommended that all probes to altitudes beyond 10,000 miles consider use of the DIGILOCK system. It is especially suited to the payload-weight-altitude envelope of the Blue Scout Junior. AFSWC experience, facilities, contract proprietary rights, and receivers for this system can be made available to interested DOD agencies.

b. Possible sources of upsetting moments.

After fourth-stage ignition, the signal strength data indicate a precession angle of at least 55 degrees, and this angle remained constant for about 20 minutes. The precession indicates that an upsetting moment was induced into the vehicle at approximately T+ 115.22 seconds. Since no vehicle instrumentation was available to explain the source of this moment, possible causes can be determined only by conjecture.

A purge hose connected to the payload and to the third stage motor was designed to disconnect upon third-stage separation. A 2-pound pull, positioned 8 inches from the longitudinal axis, was required. Theoretical calculations reveal that this torque resulted in a 3-degree precession angle within 0.036 seconds; although this would not cause the entire observed precession angle, it is undoubtedly a contributing factor.

Another source of upsetting moments could be a malfunctioning fourth-stage motor, i.e., nozzle or case burnthrough, nozzle blowout, or separation of the propellant from the case (see section 5). If a malfunction of this type were to occur immediately after fourth-stage ignition, the precession angle could be duplicated.

Finally, if the separation of the third and fourth stages was asymetric, an upsetting moment could be induced.

c. General conclusions.

The fact that no TLM-18 station, except that at Vandenberg AFB, was able to acquire the telemetry signal appears to indicate that the payload was sufficiently off course so as not to appear within any other antenna's cone of resolution. Furthermore, an orbit calculation from the data of this one station is impossible.

The signal lock acquired at T+ 26 minutes could have been under reentry conditions. However, there is no trajectory information available to indicate that reentry did occur at this time, and the possibility is merely conjecture.

The most significant information obtained after T+ 90 seconds was from the signal strength data of the Vandenberg AFB TLM-18. However, the only real conclusion from these data is that the flight was normal until fourth-stage ignition, at which time a wobble of 55 degrees was induced by some unknown force.

This force cannot be attributed to any single cause or event. Any combination of several possible malfunctions could have caused this wobble; however, there is no means of determining if any of these malfunctions did, in fact, occur.

In view of this lack of information, it is impossible to make any final conclusion concerning the fate of Blue Scout Junior (0-2). The only statement which can be made with any degree of reliability is that an unknown malfunction occurred at fourth-stage ignition inducing a precession angle of at least 55 degrees.

d. Recommendations.

(1) Vehicle instrumentation.

Vehicle malfunctions are difficult to analyse with no vehicle instrumentation, for the only source of data beyond T+ 90 seconds is signal strength data. It is recommended that in the future each vehicle be instrumented so that some additional record of performance is available. One longitudinal and one lateral accelerometer are considered minimal.

(2) Position acquisition.

An accurate means of position acquisition through powered flight must be provided. Since the FPS-16 radar is incapable of tracking this vehicle with continued accuracy beyond second-stage burnout, no accurate position data were available beyond this point. No orbit calculation was possible from the angular data observed by the Vandenberg AFB TLM-18, since the orbit solution assumes an indeterminate form because the TLM-18 was nearly in the orbit plane.[2] As a minimal requirement, one telemetry tracking station, with an assumed tracking resolution of 3 degrees, should be located at least 15 degrees out of the orbit plane . This would enable an approximate orbit solution to be obtained for malfunctions occurring during powered flight.

(3) Storage facilities.

Environmental storage facilities should be provided so that the vehicle motor temperature can be maintained within the manufacturer's recommended limits. Blue Scout Junior (0-2) rocket motors were allowed to fall below the recommended minimum temperature. According to the ARC representative, this resulted in a separation of the propellant from the casing in one of the two fourth-stage motors which were on hand. Moreover, the low temperature of the propellant causes slower burning which results in decreased thrust.

REFERENCES

1. Special Projects Division, Research Directorate, AFSWC, Kirtland AFB, New Mexico, Trajectory and Aerodynamic Information for Blue Scout Junior, PMR Test Code 0-2, Vol I and II, June 1961.

2. Baker and Makemson, An Introduction to Astrodynamics, page 151, Academic Press, New York and London, 1960.

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1	DCAS (Technical Data Center), AF Unit Post Office, Los Angeles 45, Calif
	SSD (Space Systems Division), AF Unit Post Office, Los Angeles 45, Calif
1	SSVB, Lt Col Stine
1	SSZN, Maj Kester
1	SSVT, Maj Berry
1	ESD (ESAT), Hanscom Fld, Bedford, Mass
	AFMTC, Patrick AFB, Fla
1	DWZS, Lt Col J. G. Henry
1	DAR/AFMTC-MTQU, Lt Col Hormats
	KIRTLAND AFB ORGANIZATIONS
	AFSWC, Kirtland AFB, N Mex
1	SWEH
15	SWOI
1	SWR
1	SWT
3	SWRJ
1	SWRB

DISTRIBUTION (con't)

No. Cys	
1	SWG
5	SWTTS
1	SWRP

ARMY ACTIVITIES

1	Commander, Army Ballistic Missile Agency (Tech Library), Redstone Arsenal, Ala
1	Director, Ballistic Research Laboratories (Library), Aberdeen Proving Ground, Md
1	Commanding General, White Sands Missile Range (Technical Library), White Sands, N Mex

NAVY ACTIVITIES

	Commander, Naval Air Missile Test Center, Point Mugu, Calif
3	Maj Childs
2	Safety Range

OTHER DOD ACTIVITIES

1	Chief, Defense Atomic Support Agency, ATTN: Maj McCormac, Wash 25, DC
1	Director, Advanced Research Projects Agency, Department of Defense, ATTN: Maj John Paulson, The Pentagon, Wash 25, DC
10	ASTIA (TIPDR), Arlington Hall Sta., Arlington 12, Va

AEC ACTIVITIES

1	President, Sandia Corporation, ATTN: Mr. Stan Reynolds, Sandia Base, N Mex

OTHER

1	Official Record Copy (SWTTS)

Air Force Special Weapons Center, Kirtland AF Base, New Mexico.
Rpt. No. AFSWC-TDR-62-24, FINAL REPORT FOR BLUE SCOUT JUNIOR FLIGHT 02. 38 pages incl illus., 2 refs. March 1962
UNCLASSIFIED Report

This document contains the results of the Blue Scout Junior Flight 0-2 (PMR Test Code A), which was launched from Pt Arguello, Pacific Missile Range, on 4 December 1961.

Although this flight was unsuccessful, data were obtained from FPS-16 skin track radar, which is accurate until second-stage burnout, and from TLM-18 signal strength data. Since no vehicle instrumentation was aboard this flight, causes of failure cannot be accurately determined. Motor

1. Blue Scout Junior
2. Flight testing
3. High altitude instrument carriers
4. Protons -- measurement
5. Radar tracking systems
6. Radiation belts
7. Telemetering systems

I. AFSC Project 7811
II. J. M. Kamm, Jr., Capt USAF
III. In ASTIA collection

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